REMARKS

In view of the above amendments and the following remarks, reconsideration of the rejections contained in the Office Action of June 4, 2003 is respectfully requested.

The Examiner has objected to the drawings because they do not include reference number 5 mentioned in the specification. In view of this objection, and in order to make several additional editorial corrections to the drawings, a set of new Figures 1-6 has been prepared and submitted herewith as explained in more detail below.

As an initial matter, new Figures 1-6 include the proposed drawing amendments filed on March 20, 2002, and approved by the Examiner in the outstanding Office Action. In addition, Figures 1 and 2 have been amended in order to include reference number 5 mentioned in the specification. Thus, it is submitted that the Examiner's objection to the drawings has been overcome. In addition, Figure A1 has been re-labeled as Figure 4 and Figure A2 has been re-labeled as Figure 5 in order to comply with current practice regarding drawings, and original Figure 4 has been re-labeled as Figure 6 in view of the changes to Figure A1 and Figure A2 discussed above. Finally, the two occurrences of the term "utilisation" in Figure 5 have been changed to "utilization", and the two occurrences of the term "optimisation" in Figure 6 have been changed to "optimization" in order to replace the European spelling of these terms. It is submitted that these changes do not add any new matter to the drawings, and the Examiner is respectfully requested to enter these new formal drawings.

The Examiner has objected to the specification because there is no brief description of drawing Figure A2, and because the brief description of Figure A1 is unclear. In order to address these objections and make several additional editorial corrections, the entire specification and abstract have been reviewed and revised. In particular, the specification has been revised in order to provide consistency between the reference numbers used in the specification and the drawing amendments discussed above, and in order to make idiomatic and grammatical changes. However, no new matter has been added by any of the changes to the specification. Due to the number of changes, a substitute specification and abstract has been prepared and submitted, and a marked-up copy of the original specification showing the changes made has also been submitted. The Examiner

is respectfully requested to enter the substitute specification and abstract. In view of the preparation and submission of the substitute specification, it is respectfully submitted that the Examiner's objections to the specification have been overcome.

The Examiner has rejected claim 22 under 35 USC § 112, second paragraph, as being indefinite. In view of this rejection, and in order to place the original claims in a preferred form, claims 13-27 have now been cancelled and replaced with new claims 28-47. Although the new claims have been drafted to generally correspond to the original claims, none of the new claims correspond to original rejected claim 22. Furthermore, the new claims have been carefully drafted so as to fully comply with all the requirements of 35 USC § 112. Consequently, it is respectfully submitted that the Examiner's rejection under § 112 is not applicable to the new claims.

The Examiner has rejected claims 13-27 as being anticipated by the Copple reference (USP 5,443,330), and as being anticipated by the Nista reference (USP 5,094,567). However, as indicated above, claims 13-27 have now been cancelled and replaced by new claims 28-47, including new independent claims 28, 41, and 47. For the reasons discussed below, it is respectfully submitted that new claims 28-47 are clearly patentable over the prior art of record.

New independent claims 28 and 47 are directed to a tether system for anchoring a tension leg platform to the sea bed, and independent claim 41 is directed to a tension leg platform system. Each of these new independent claims recites *a plurality of hollow and watertight tethers operable to withstand a tension force to be generated between a tension leg platform and the sea bed.* Independent claims 28 and 41 recite that each of the tethers includes an upper section and a lower section, and the upper section has a larger diameter than the lower section. Alternatively, independent claim 47 recites that each of the tethers includes pipe sections having different diameters so that each of the tethers has a continuous reduction in diameter from the tension leg platform to the sea bed. These features provide significant advantages as discussed below.

As explained in paragraph 4 on page 1 of the original specification, a tension leg platform is semi-submersible floating platform anchored to foundations on the sea bed by tethers. Because each of the tethers is designed so as to be operable to withstand tension forces (created by ocean currents, waves, and tide patterns of the sea in which the tension leg platform is to float), the tethers

will prevent excessive movement of the tension leg platform and provide stability. Furthermore, the lower section of each tether has a greater pressure resistance in order to withstand the greater pressures at greater depths. However, because each of the tethers is hollow and watertight, and because the diameter of each of the tethers decreases from the tension leg platform to the sea bed, the water weight of the upper section and lower section of each tether will balance out (i.e., each tether can therefore have a desirable neutral buoyancy).

The Copple reference discloses a deep water platform with buoyant flexible *piles* (i.e., support columns). In particular, as illustrated in Figure 3 of the Copple reference, each flexible pile 10 supports the weight (or a portion of the weight) of a platform 100. In other words, the pile 10 must be designed to support *compressive* forces, but the Copple reference <u>does not</u> disclose or suggest tethers operable to withstand a *tension* force to be generated between a tension leg platform and the sea bed. In addition, as explained in column 1, lines 51-60 of the Copple reference, the piles are partially filled with sea water. Thus, the Copple reference also <u>does not</u> disclose or suggest *hollow and watertight tethers*. Consequently, it is respectfully submitted that the Copple reference does not anticipate or even suggest the invention recited in new independent claims 28, 41, or 47.

The Nista reference is directed to a flexible *column* formed of a composite material. However, as illustrated in Figure 1 of the Nista reference, the columns are provided to support a platform A so as to withstand *compressive* forces. Thus, the Nista reference <u>does not</u> disclose or suggest tethers that are operable to withstand *a tension* force to be generated between a tension leg platform and the sea bed. Moreover, the Nista reference explains that each column is tapered so as to have an *increase* in outside diameter from the surface toward the sea bed (see column 3, lines 15-17), which is in clear contrast to the present invention in which each of the tethers has a *reduction* in diameter from the surface to the sea bed. Therefore, it is respectfully submitted that the Nista reference does not anticipate or even suggest the invention recited in new independent claims 28, 41, or 47.

As explained above, the Copple reference and the Nista reference do not disclose or suggest a system comprising a plurality of hollow and watertight tethers operable to withstand a tension force to be generated between a tension leg platform and the sea bed, in which each of the tethers has a

reduction in diameter from the tension leg platform toward the sea bed. Therefore, one of ordinary skill in the art would not be motivated by these references so as to obtain the invention recited in independent claims 28, 41, and 47. Accordingly, it is respectfully submitted that independent claims 28, 41, and 47, and the claims that depend therefrom, are clearly patentable over the prior art of record.

In view of the above amendments and remarks, it is submitted that the present application is now in condition for allowance. However, if the Examiner should have any comments or suggestions to help speed the prosecution of this application, the Examiner is requested to contact the Applicant's undersigned representative.

Respectfully submitted,

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TITLE

Version with Markings to Show Changes Made

Deep water TLP Tether System

BACKGROUND OF THE INVENTION

[0001] This invention relates to ~~the art of~~ offshore structures and, more particularly, to tension leg platforms (TLP) for exploitation of deep sea hydrocarbon reserves.

[0002] Mooring elements, or ~~tethers~~ tethers, on tension leg platforms are anchored to the seabed. They usually consist of steel pipes and are kept in tension by the buoyancy of the platform.

[0003] With the gradual depletion of onshore and shallow sub sea subterranean hydrocarbon reservoirs, the search for additional petroleum reserves is being extended into deeper and deeper waters. As such deeper reservoirs are discovered, increasingly complex and sophisticated production systems are being developed. It is projected that soon, offshore exploration and production facilities will be required for probing depths of 1500m or more.

[0004] One way of reaching these depths is by using Tension Leg Patforms. A TLP comprises a semi-submersible-type floating platform anchored to foundations on the sea bed through members or mooring lines called tension legs or tethers. The tension legs are maintained in tension at all times by ensuring that the buoyancy of the TLP exceeds its operating weight under all environmental conditions. The TLP is compliantly restrained by this mooring system against lateral offset allowing limited surge, sway and yaw. Motions in the vertical direction of heave, pitch and roll are stiffly restrained by the tension legs.

[0005] External flotation systems can be attached to the ~~legs~~ legs, but their long-term reliability is questionable. Furthermore, added buoyancy of this type causes an increase in the hydrodynamic forces on the leg structure.

[0006] ~~TLPs'~~ TLPs based on today's technology are considered competitive down to 1,000-1,500m. Beyond this depth, the tether system becomes increasingly heavy, requir-

ing an increased platform size to carry the tether weight. This results in a larger platform, which has a significant impact on the overall cost.

[0007] For a TLP at 3,000m, a conventional tether system (one thickness, one diameter) ~~represent~~ represents a weight almost equal to the payload. In previous designs, it has been proposed to reduce the wall thickness at the top to reduce the weight penalty. A solution to avoid these disadvantages related to the ~~TLP,~~ TLP is to modify the tether system to reduce the need for increased hull size. The industry has devoted a considerable effort to develop tether systems based on various designs. Filling tether pipes with low-density material, ~~pressurising~~ pressurizing the interior to increase the hydrostatic ~~capacity~~ capacity, and replacing the steel tether pipes ~~by~~ with composites are examples of these efforts.

[0008] Another solution can be found in NO 1997 3044, showing a design used for depths down to 700 m, built by pipe sections with a diameter between ~~0,5 to 1,2 m~~ 0.5 and 1.2m. The overall buoyancy of the tension leg is meant to be more or less neutral. This is achieved by adding an additional floating body at the top of the pipe.

[0009] NO 1997 3045 shows a welding connection on a tension leg. The publication shows two pipes ~~of~~ having different ~~diameter~~ diameters and wall ~~thickness~~ thicknesses welded together.

[0010] GB 2 081 659 A shows a floating platform mooring system for use in exploiting sub sea oil ~~shoals that consists of~~ shoals, and includes a platform structure and an array of vertical tubular anchoring lines connected to the upright of the platform structure and to anchoring blocks on the sea bed. The patent shows anchoring lines consisting of a steel tube having resistance to yield stresses and having upper and lower sections. The upper section is a steel rod with a flexural stiffness which decreases from its point of connection to the upright. The lower section of the anchoring line has a hollow configuration and is fixed to an anchoring block in order to achieve an optimum exploitation of the structural material.

[0011] However, the patent does not address the problems relating to the weight and pressure resistance of deep sea tension legs.

SUMMARY OF THE INVENTION

[0012] The object of the present invention is to overcome the above-mentioned ~~deficiencies~~ deficiencies, and to design tethers for ~~TLP's~~ TLPs that ~~reduces~~ reduce the necessary added payload on the platform due to the tether weight. This object is achieved by providing a TLP as ~~defined in the appending claims~~ described below.

[0013] The invention relates to a tether system for ~~TLP's, with~~ TLPs including tethers having upper and lower pipe sections, in which the tethers ~~having a reduction of the~~ having a reduced diameter towards the seabed. The invention is a concept for modifying today's technology for use in ultra deep waters. By introducing reductions in the tether diameter, the lower sections of the tether towards the sea bed will normally be negatively buoyant because of the considerable wall thickness necessary to withstand the hydrostatic pressure. The upper sections can more easily be made buoyant (due to less wall thickness), because the hydrostatic pressure is closer to the surface. This will help to balance the overall weight of the upper and lower sections.

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[0014] The tether pipes are dimensioned to carry the tension from a platform consisting of a nominal pre-tension plus the tension variation ~~by~~ due to functional and environmental loads. The pipes are kept ~~empty,~~ empty (i.e., watertight and hollow) to reduce the ~~weight/increase~~ weight and increase buoyancy. The pipes must not only be designed to withstand the loads applied by the platform, but must also ~~has~~ be able to resist the hydro-

static pressure from the surrounding sea. This becomes more prominent as the ~~depth/hydrostatic~~ depth and

hydrostatic pressure increases. At great depths (in the order of 1,000m) the pipes can no longer be designed to have a neutral buoyancy (a diameter to thickness ratio of about 30). In order to withstand the pressure, the diameter to thickness ratio has to be reduced, which results in added load on the platform.

[0015] The thickness of each section is sized according to capacity. It should also be considered that the tether vertical stiffness is critical for performance, and it is therefore ~~favourable~~ favorable to maintain a fairly equal ~~stiffness/length~~ stiffness and length of each section.

[0016] The reduction ~~of~~ in overall diameter will typically be made in steps, with intersections between the steps. The number of steps will depend on the length of the ~~tether/depth of which it is to be used etc~~ tether (i.e., the depth at which the tether will be used. In-between each diameter, a transition piece carries the load. This is a well-proven detail from previous TLP designs. The tethers may have a gradual transition between the upper and lower sections instead of the above described steps, but such tethers are less likely to be used because such tethers probably will require a more complex manufacturing process.

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[0017] With near neutral tethers, the reduction of the hull weight is in the order of 30 percent as compared to the hull weight when tethers according to the prior art are used. This is due to the decrease of added payload when tethers of the invention are used.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] The invention will now be explained in more detail, with reference to the drawings in ~~which~~ which:

[0019] Figure 1~~-shows~~ is a schematic view showing a tension leg platform with tethers according to the present invention;

~~Figure A1 shows the tension distribution of the two concepts;~~

Figure 2~~-shows~~ is a schematic view showing a tether string according to the invention;

~~Figure A2 shows a schematic representation of tether pipe utilization.~~

Figure 3~~-shows~~ is a cross-~~section~~ sectional view of a diameter transition section;~~-and~~

Figure 4 is a graph comparing the tension distribution of a uniform diameter pipe and a stepped diameter pipe;

~~Figure 4 shows an optimisation chart where a tethers outer diameter and the wall thickness are plotted to show how buoyancy, stiffness and hydrostatic capacity varies.~~

Figure 5 is a graph comparing tether pipe utilization of the uniform diameter pipe and the stepped diameter pipe; and

Figure 6 is an optimization chart on which an outer diameter and a wall thickness of a tether are plotted to show how buoyancy, stiffness and hydrostatic capacity varies.

DETAILED DESCRIPTION OF THE INVENTION

[0020] The following~~-gives~~ is a description of an embodiment provided by way of the following non-limiting example.

[0021] A tension leg platform (4) with one step and two tethers (6) ~~having two diameters~~ holding the platform is shown on Fig 1. Each tether 6 includes a large-diameter upper section (1) and a small-diameter lower section (2), so that the sections have two

different diameters. A transition piece (3) located between the ~~diameters~~ tether sections is shown ~~on~~ in Fig 3 in detail. ~~An~~ The upper ~~part of a~~ section (1) of each tether ~~(1)~~ (6) may ~~then~~ have a diameter of 142 mm and a wall thickness of 24.5 mm, whereas the lower ~~part~~ section (2) has an outer diameter of 76 mm and a wall thickness of 42 mm. The tethers are anchored to foundations (5).

[0022] A tether with two steps (three sections) is shown on Fig 2. The figure shows three tubular sections, including an upper section (1), a lower section (2), and an intermediate section (7), interconnected with two transition pieces (3). The three tubular sections have successfully reduced diameters towards the sea bed. In other words, each section of the tether has a diameter smaller than the diameter of an adjacent section located farther from the sea bed.

~~The figure shows three tubular sections interconnected with two transition pieces (3). The three tubular sections have a reduction of the diameter towards the sea bed.~~

[0023] Figure ~~A2~~ A5 is a ~~schematic~~ graphic representation of tether ~~part~~ pipe utilization.

[0024] Samples of further variations in loads, dimensions and configurations are illustrated in Table 1. The embodiment suggests a wellhead platform in a West African environment. The deck weight includes the facilities, the structural ~~steel~~ steel, and the operational loads, including the riser tensions. The riser tensions are increased with water depth. The hull and displacement are increased to carry the deck load and the tether pretension.

[0025] The thick tether system represents the conventional ~~one thickness~~ tether having only one thickness, which has to have a large ~~thickness to diameter ratio,~~ thickness-to-diameter ratio to withstand the hydrostatic pressure at the bottom (i.e., near the sea bed). The stepped tether system represents the present invention, which allows for a reduction of the tether pretension. This allows for a reduction of the displacement and of the hull weight.

Table 1 West Africa TLP Application

WATER DEPTH	(m)	1000m	1500m		2000m		3000m		
TETHER SYSTEM	**(-)**	**THICK**	**THICK**	**STEPPED**	**THICK**	**STEPPED**	**THICK**	**STEPPED**	**MAX. STEP**
DECK WEIGHT	(t)	4,800	5,000	5,000	5,300	5,300	5,900	5,900	5,900
RISER TENSION	(t)	2,800	4,200	4,200	5,600	5,600	8,400	8,400	8,400
HULL & BALLAST	(t)	5,300	6,000	5,800	7,100	6,400	10,100	8,200	7,700
TETHER PRETENSION	(t)	2,400	3,300	2,600	5,500	3,000	13,000	6,200	4,500
DISPLACEMENT		**15,300**	**18,500**	**17,600**	**23,500**	**20,300**	**37,400**	**28,700**	**26,500**

TETHERS									
NO. OF DIAMETERS		1	1	2	1	2	1	5	10
DIAMETER (top/bott.)	Inch	26	30	46/24	32	52/28	34	56/30	56/30
DIAMETER (top/bott.)	mm	66	76	117/61	81	132/71	86	142/76	142/76
THICKNESS (top/bott)	mm	22.2	28.5	38.5/23	35.5	34.5/31	47.5	24.5/42	24.5/42
MAX. LOAD – TOP	(kN)	7,200	8,900	8,100	12,400	8,000	24,000	14,700	12,600
WEIGHT in WATER	(t)	0	70	-10	300	20	1,100	300	70

[0026] The above described embodiments use steel as the construction material, but the invention is also meant to cover other materials such as composites.

ABSTRACT

~~The invention proposes to increase the diameter of the top sections (2) of the tethers on~~ A tether system includes tethers each having an upper section (1) attached to a tension leg ~~platforms (TLP)~~ platform (TLP) (4) ~~to the make top sections~~, and each upper section has a large diameter so that the upper section (1) is positively buoyant. This buoyancy can be designed to compensate for the weight of the lower ~~sections~~ section (2) of each tether, so as to make the total buoyancy of ~~the~~ each tether closer to neutral. The selection process for each section is driven by requirements for buoyancy, stiffness and external pressure resistance.